

*The Impact of Large-Scale Surveys on Pulsating Star Research, IAU Coll. 176
ASP Conference Series, Vol. ???, 1999
L. Szabados and D.W. Kurtz, eds.*

Studies of Mira and semiregular variables using visual databases

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Abstract. We use wavelets to investigate period and amplitude changes in Mira and semiregular variables and found a variety of behaviours. Period and amplitude changes often go together, perhaps because changes in amplitude are causing period changes via non-linear effects.

Wavelet analysis is useful for tracing changes in the periods and amplitudes of long-period variables. We have already published results for the semiregular R Dor, which appears to switch between two modes on a timescale of decades (Bedding et al. 1998). See also the work of Szatmáry, Kiss and coworkers (Kiss et al. 1999 and these Proceedings), and of Andronov (these Proceedings).

In the case of Miras, a few stars are known to have long-term period trends that may be related to adjustment after a helium-shell flash (Wood & Zarro 1981). A good example is R Aql, which has a gradually decreasing period and, as clear in Fig. 1, a previously unnoticed decrease in amplitude. We find a similar effect in other Miras known to have changing periods, such as W Dra and BH Cru (period and amplitude both increasing) and R Hya and T UMi (periods and amplitudes decreasing). The case of BH Cru is shown in Fig. 2.

Other stars such as S Ori (Fig. 3) show repeated period changes, but still with matching amplitude changes. We suggest that, at least in some cases, the amplitude changes might *cause* the period changes via non-linear effects.

Acknowledgments. We thank the many observers and those who maintain the visual databases of the AAVSO, RASNZ, AFOEV, VSOLJ and BAAVSS.

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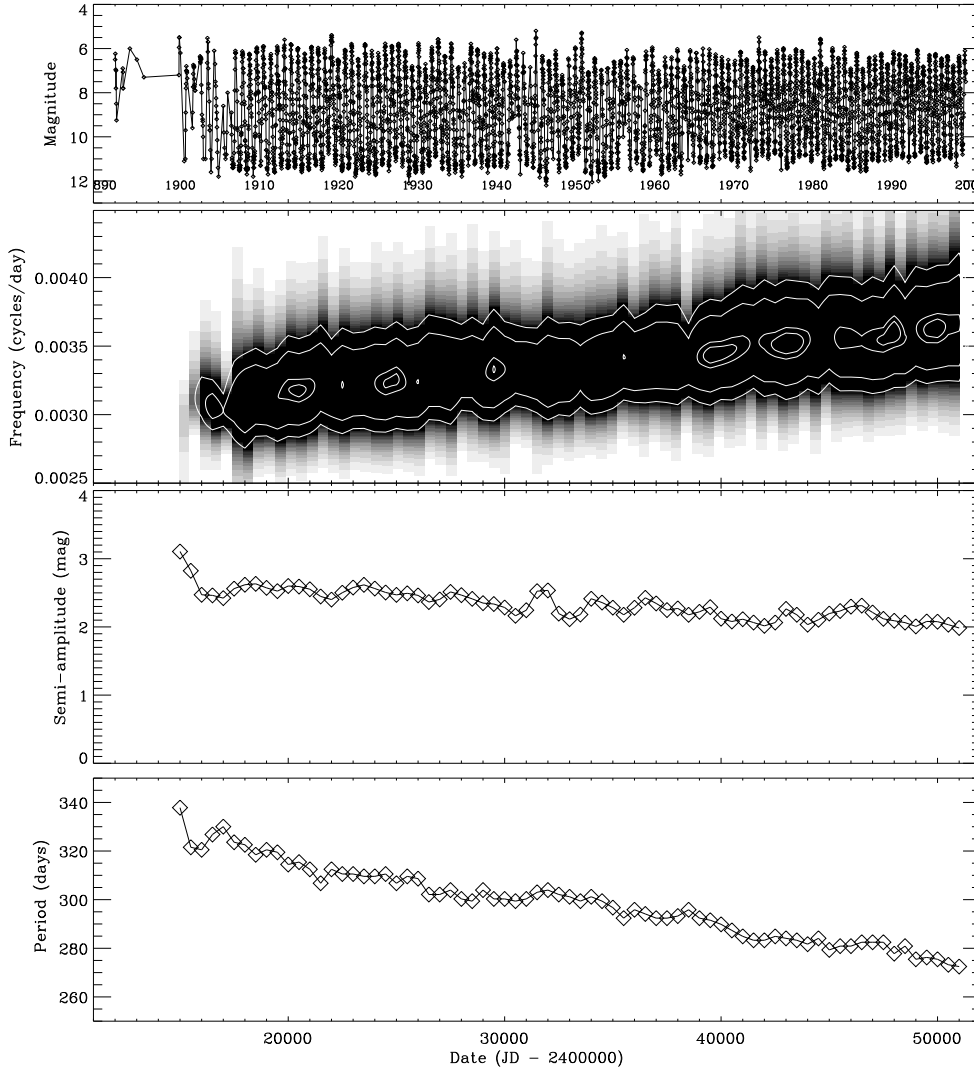


Figure 1. Analysis of visual observations of R Aql. The top panel shows the light curve averaged in 5-day bins, from data supplied by the AAVSO, AFOEV, VSOLJ and BAAVSS. The second panel shows the WWZ wavelet transform, while the third and fourth panels show time evolution of the semi-amplitude and period, respectively. As described by Bedding et al. (1998), we use the wavelet implementation by Foster (1996), with the semi-amplitude and period being derived from the WWA rather than the WWZ.

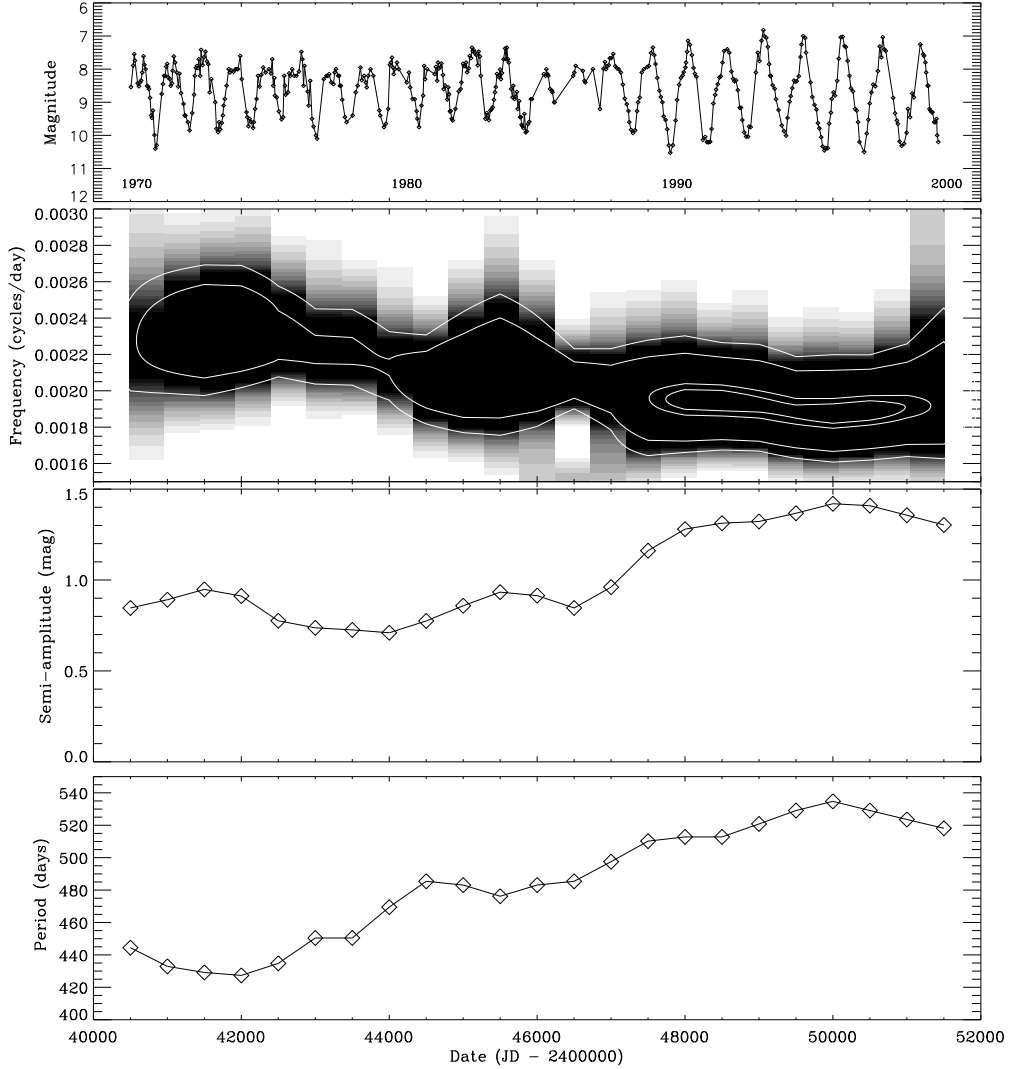


Figure 2. Same as Fig. 1 but for BH Cru, from data supplied by the RASNZ and averaged in 10-day bins. Our analysis confirms the suggestion by Bateson et al. (1988) that period of BH Cru is increasing. The rate of period change ($\dot{P} = 0.012 \text{ d d}^{-1}$) is the largest we have found for any Mira. Meanwhile, as pointed out by Walker et al. (1995) and confirmed by Hipparcos photometry, the double maxima in the light curve have now disappeared. As reviewed by Whitelock (1998), the spectrum of this star has changed from O-rich to C-rich, perhaps after dredge-up, and it is possible the period, amplitude and light curve changes are also related to a recent dredge-up event.

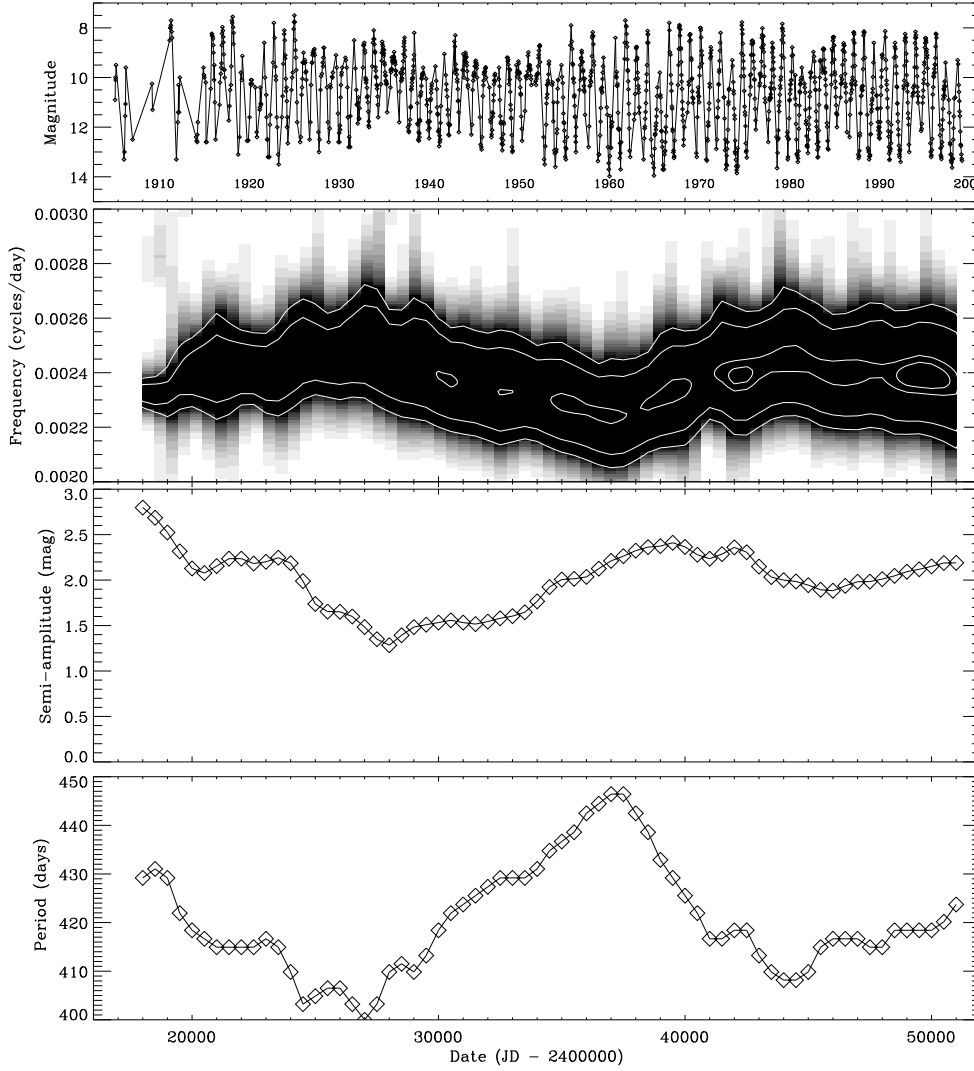


Figure 3. Same as Fig. 1 but for S Ori, from data supplied by the AAVSO, AFOEV and VSOLJ and averaged in 10-day bins. Period changes in this star are noted in the *General Catalogue of Variable Stars* and also by Percy & Au (1999). Here, we see changes both in period and period derivative (\dot{P}). In fact, the period has not been constant at any time in the last 100 years, with \dot{P} changing sign every few decades. Note that the true behaviour is difficult to recognise in the $O - C$ diagram (not shown), since a change in \dot{P} must be deduced from a change in curvature.